# Integrated Rain Water Management Strategies in the Blue Nile Basin of the Ethiopian Highlands

Birhanu Z. Birhanu[1*], Matthew McCartney[1], Bharat Sharma[2], Joshua Ogunwole[3], Gerba Leta[1] and Seleshi B. Awlachew[1]

[1]International Water Management Institute (IWMI), Addis Ababa, Ethiopia

[2] IWMI, New Delhi, India, [3] Visiting Soil Scientist, Nigeria

[*] E-mail of corresponding author b.zemadim@cgiar.org

**Abstract**

This paper describes the research that the International Water Management Institute (IWMI) and partners are undertaking as part of the Challenge Program on Water and Food (CPWF) Nile Basin Development Challenge (NBDC). The work is being conducted in collaboration with three national universities: Ambo, Bahir Dar and Wollega and is intended to increase understanding of how to plan successful Rain Water Management (RWM) strategies and identify how these can be effectively implemented. The project focuses on integrated rainwater management strategies – technologies, institutions and policies - for the Ethiopian highlands of the Blue Nile Basin. Three Woredas, Jeldu, Fogera and Diga, have been identified for the study. These were selected because they represent farming systems that are common in the Ethiopian Highlands. Within each, nested sites have been identified for learning and research at a variety of physical and social scales. In each Woreda, one "action research catchment" has been identified as follows: Meja watershed (93 $km^2$) in Jeldu Woreda, Dapo watershed (18 $km^2$) in Diga Woreda and Mizewa watershed (27 $km^2$) in Fogera Woreda. In the action research catchments hydro-meteorological instrumentation will be installed and the data collected will be analyzed to gain understanding of hydrological processes. This will in turn provide the basis for hydrological modeling that can be used to determine how the study landscapes may be influenced by RWM interventions. In the identified landscapes the work integrates land and water management, crop component technology, crop management, crop livestock systems, pastoral systems and even agro-forestry systems with the intention of raising agricultural water productivity and livelihood incomes. The baseline status of the three study sites and critical constraints for adoption of integrated RWM are included in this paper. The paper also describes common RWM practices and lessons learned from experience in India. Differences in the socio-economic and biophysical context mean that care is needed in transferring approaches between countries. Nevertheless, it is believed that knowledge gained from the extensive Indian experience can usefully inform practices in Ethiopia.

**Keywords:** Blue Nile Basin, Diga Woreda, Ethiopian Highlands, Fogera Woreda, Jeldu Woreda, Rain Water Management, Watershed Development Program

## 1. Introduction

The Ethiopian highlands of the Blue Nile basin are characterized by rainfall of between 900 mm and 2500 mm. However, this relatively high rainfall is not easily retained in the form of surface

water or ground water. The frequent occurrence of intense precipitation in the highlands causes much of the water to be lost to runoff making life difficult for the majority of people whose livelihoods are rain-dependant. As the landscapes in the highlands are ecologically fragile, poverty and marginalization are typical characteristics of the rural villagers living in the areas. Poor land management practices and a lack of focus on effective Rain Water Management (RWM) programs exacerbate the situation. A recent report, the Ethiopian Strategic Investment Framework for Sustainable Land Management (ESIF-SLM, 2010) reported that though the highlands of Ethiopia have enormous agricultural and natural resources potential, the lack of land management programs in the past have resulted in improper land use and consequently severe consequences for livelihoods. Similarly, the Ethiopian Reporter (a bi-weekly Amharic and English news paper) reported that Rain Water Harvesting (RWH) and its utilization has been ranked as poor in six regional states of Ethiopia. The report referred to the diagnostic research conducted by the Ethiopian RWH association and cited major problems as: i) the structures built to harvest rainwater were not built to the required standard and cannot contain enough water; ii) there was no close supervision of the structures; iii) the approaches lack community cooperation, iv) most structures were built rapidly with poor planning and lack of decentralized ownership systems (Reporter, 2010). The result of poor planning and construction of such structure is hardship and insecurity. Rather than bringing benefits the vicious cycle of poverty is aggravated. For poor communities living on fragile and degraded hillsides actions must address the deteriorating environmental conditions that undermine their livelihoods and their capacity to cope with disasters (WRI Report, 2003).

With limited resources and access to external services communities in the Ethiopian Highlands are unable to safeguard their livelihood systems. Improving the resilience of these communities is of utmost importance and requires a focus on issues of land degradation and water scarcity. This is because land degradation and water scarcity are the most intense and common problems of many rural Ethiopians living in highland areas. Land degradation, for example, has been identified as a contributing factor to low /poor agricultural productivity. Overall, the annual costs of land degradation are estimated to be at least 2-3% of agricultural GDP (ESIF-SLM, 2010). The land degradation and associated water scarcity are multi-dimensional problems, which the piecemeal efforts of different agencies have failed to tackle effectively in the past (ESIF-SLM, 2010). Thus the major goal of RWM strategy should be to contribute to poverty reduction and improve the quality of life of the rural communities. Effective RWM in highland catchments should be based on natural resource regeneration and management. Restoration of the local environment through RWH is possible only if there is a focus on the entire watershed and integrated community-led approaches are adopted. Hence, all environmental regeneration and management programs should have an environmental unit for planning and implementation.

This paper focuses on a watershed approach towards RWM in three action research catchments of the Blue Nile basin of Ethiopia. The Woredas are: i) Fogera in North-Western Ethiopia (a relatively high potential, market-oriented, rice–based system); ii) Jeldu in central Ethiopia (a relatively low-potential system with steep agro-ecological gradients) and iii) Diga in Western Ethiopia (a relatively high potential system with poor market access but with high value crops and livestock potential) (CPWF E-Letter, 2010). It is believed that action research catchments within these Woredas are the best environmental units for a development initiative in RWM in which the issue of water scarcity, environmental degradation and livelihood can be addressed.

## 2. Existing Practices of RWM in Ethiopia

Both traditional RWH techniques (such as runoff farming) and in-situ water harvesting techniques (such as micro-basins) are used in Ethiopian (Johnston and McCartney, 2010). A recent study (AMU, 2009) revealed that from 40,000 RWH ponds constructed between 2003 and 2008 in Amhara and Tigray region of Ethiopia, most have failed. In-situ water harvesting structures are made from plastic PVC, sheet metal and reinforced concrete and are put above and below the ground surface. However most of these structures were found to be not complete in their construction and lack close monitoring after their construction, and hence cannot store water effectively during rainy season (Reporter, 2010).

Runoff farming practices which are closely related to the Soil Water Conservation (SWC) program date back to 1970 in Ethiopia. This program targets reducing soil erosion with little or no interest in enhancing soil water infiltration. With slow uptake by local farmers, the program faces a lot of challenges. Farmers state that their participation was enforced by agricultural extension officers rather than self-motivated. What also makes SWC programs unsuccessful is that the technologies are rarely sufficiently adapted to local conditions (Bewket and Sterk, 2002; Amsale and de Graaff, 2007). In conjunction with SWC programs measures like protecting forested areas and reducing soil erosion by building terraces and planting tree seedlings have been ongoing since the mid-1970s, but with limited success (Bishaw, 2001).

There are few successful stories of RWM programs as part of the Sustainable Land Management (SLM) project by the Ministry of Agriculture and Rural Development (MoARD). The projects that are showcased in Amhara, Oromiya, Tigray and Somali region include various technologies and approaches to increase in-situ water availability and increase aquifer recharge. These are explained in Section 6 of this paper. However those technologies and approaches that are termed as successful by MoARD have not been properly documented and reported (SLMP, 2010). Hence scaling up of best practices on SLM and identification of appropriate types of technology of water storage options in specific situations has been a challenging phenomenon in Ethiopia (SLMP, 2010; Johnston and McCartney, 2010).

## 3. Research Sites

The research is being conducted in areas (called “study landscapes”) representing dominant agro-ecological zones and farming systems. Three study landscapes (Table 1) within the three Woredas were selected as a nested set of sites for learning and research at a variety of physical and social scales (Fig 1). Within each study landscape, “action research catchments” were identified as follows:

- Dapo watershed (18 $km^2$) in Diga,
- Mizewa watershed (27 $km^2$) in Fogera and
- Meja watershed (93 $km^2$) in Jeldu.

In each of the action research catchments it is planned to install hydro-meteorological instruments (comprising flow, rainfall, weather, and soil moisture and groundwater measurements) to provide insights into hydrological processes and water fluxes at different scales. The objective of this monitoring is to provide baseline data for evaluating RWM strategies, and water-use and water productivity in different landscape components. Data

obtained will be used in conjunction with computer models (e.g. SWAT and WEAP) to evaluate the possible implications (including downstream impacts) of scaling up interventions. Data will be collected for two-years (i.e. 2011-2012).

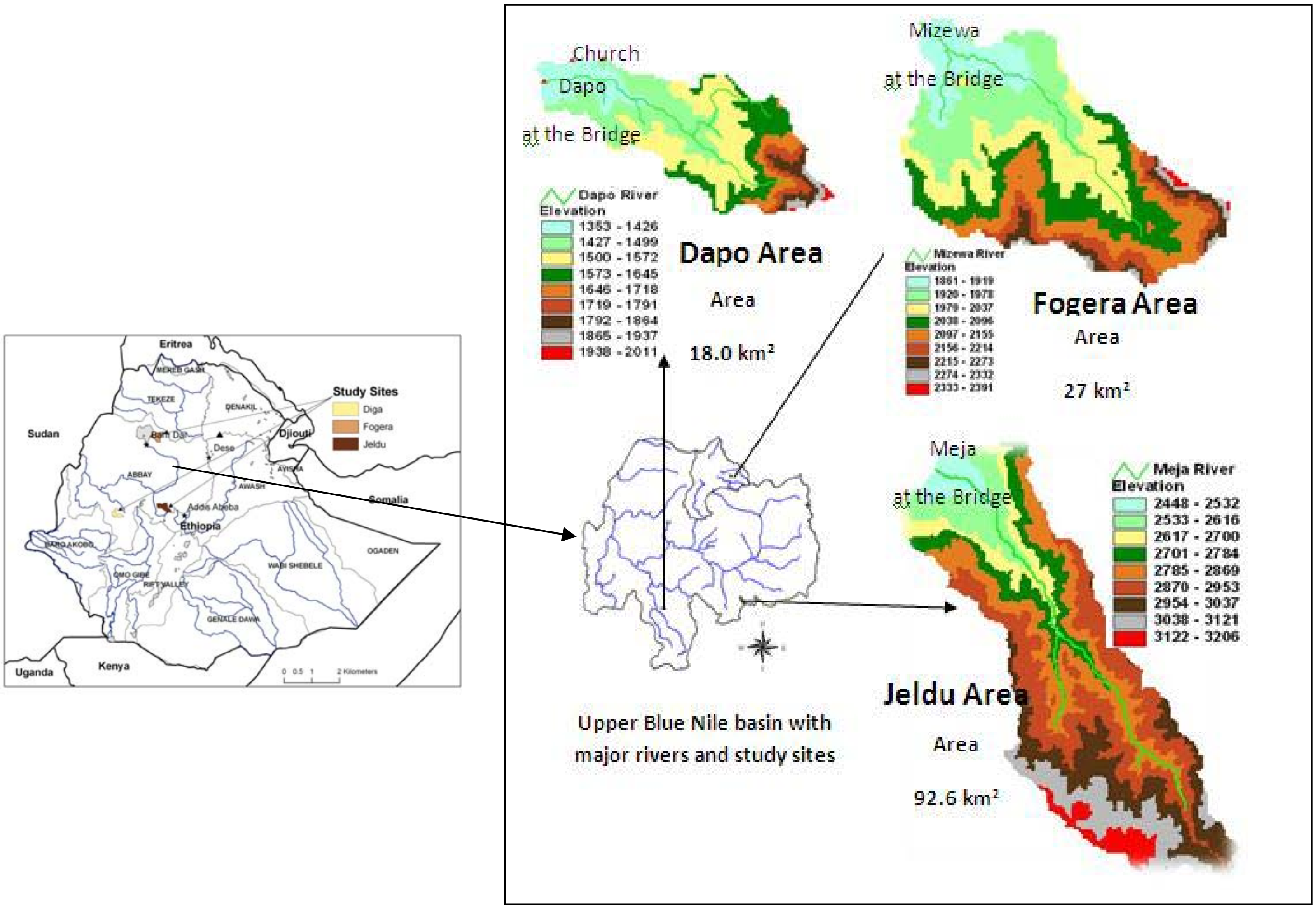


Fig 1. Location of research sites

Table 1. Selected study landscapes

| Landscape | Woreda | Predominant farming systems | Mean annual rainfall (mm) |
|---|---|---|---|
| Diga/ Dapo watershed | Diga | In the lowland maize is the dominant crop followed by sorghum, millet & sesame and perennial crops coffee & mango. In the midland, teff, millet & maize are important in that order. Livestock keeping is common allover therefore, the farming system is: "Mixed crop-livestock system" | 1,376 – 2,037 |
| Fogera/ Mizewa watershed | Fogera | Rice is the major crop followed by maize, millet & tef, barley and ground nut. Farming system is: "Mixed crop-livestock system" | 974 – 1,516 |
| Jeldu/ Meja watershed | Jeldu | Potato, barley, wheat, faba bean & F.pea are the dominant crops in the highland area, but maize, sorghum and tef are common from mid to lowland. Except in upstream area crop rotation is largely replacing the fallowing practices due to shrinkage of the size of land possessed by individual farmers. : "Mixed crop-livestock is the common farming system" | 900 – 1,350 |

## 4. Physical Description of Study landscapes

### a) Diga Area

The Diga area, located in the south-west of the Abbay basin is bordered in the north east by Guto Gida district (Nekemt town), which is zonal capital of east Wollega, and in the west by the Didessa River, one of the major tributaries to Blue Nile River, on the north by Sasiga district and on the south and southeast by Jimma Arjo & Leka-Dulecha districts. The area is one of the highest rainfall regions of the Ethiopian highlands. In some places mean annual rainfall exceeds 2,000mm. The altitude in the area varies from 1,200 to 2,342 masl and comprises two agro-ecological zones: the lowlands and midlands (Fig 1 and Table 1). The midlands are steep, formerly forested terrain which is being rapidly cleared of trees. Large areas of forest have been cleared in the last 10 years. Scattered communities tend to cultivate the tops and bottoms of slopes because the slopes themselves are too steep. However, there is increasing cultivation of the slopes and hence increasing problems of soil erosion and loss of soil fertility. In some places all the top soil (sandy clay loams and sandy clay) has been lost. Once the productivity declines too far, farmers simply move on, clearing yet more forest, this increases the desperate marginalization of the rural poor. The lowland, bordering the Didessa River, is less steep than the midlands, comprising more rolling terrain and in recent years there has been a large influx of people into this lowland area.

Most rivers in the Woreda are perennial but in recent years scarcity of water during the dry season for livestock and people has become an increasingly common phenomenon. Local experts attributed water scarcity to: i) population pressure; ii) lack of soil conservation measure to reduce erosion; iii) deforestation; and iv) overgrazing. There is a lot of potential for irrigation, particularly on the flatter terrain of the lowlands. At least 7 of the 31 rivers in the Woreda have

the potential to irrigate 300 ha each (i.e. a total of 21,000 ha). In the last season 1,769 ha has been used/developed for traditional irrigation. Some farmers now have diesel pumps through a government scheme which distributed some 21 pumps. It is possible that up to 330 ha are irrigated with pumps. On irrigated land farmers can grow 2-3 crops per year. In some places, *Bone*, a traditional practice of cultivating in wetland areas using residual moisture, is being undertaken. It is estimated that this is practiced on 1,879 ha in the Diga woreda. Some farmers have built small ponds and reservoirs, but currently there is seemingly little real interest in rainwater harvesting practices.

**b) Fogera Area**

The Fogera area, located in the north-east of the Abbay basin, to the east of Lake Tana (Fig 1) comprises a large flat floodplain in the vicinity of the lake and contributing hilly catchments to the east. The altitude varies from 1,784 to 3,600 masl. Rainfall varies from approximately 1,000 mm on the plains to about 1,500 mm at higher altitudes. The principal rivers, the Ribb and the Gumera drain east- west, discharging into Lake Tana. In Fogera Woreda 77 perennial and 38 intermittent rivers are recognized. There are also 155 springs that are used for domestic water supply and irrigation. According to the Woreda agriculture office there are a total of 820 pumps. The Fogera plains are extensively cultivated with large areas of rice (Plate 1), vegetable (e.g. onion and maize). This area has been converted from grazing to rice in the last 5 years. Farmers utilize traditional diversions and increasingly small pumps for irrigation. The water table is shallow; typically 2- 4 m and some farmers have wells. However, the wells cannot be dug too deep as they tend to collapse. Flooding is a major problem during the wet season and though this keeps the soils fertile, water logging of maize is a common problem (Plate 1b). There are lots of rivers and the water table is high. However, local farmers reported that water scarcity is a major problem in the dry season because water is being diverted for upstream irrigation. In recent years dry season conflicts between upstream and downstream communities in this catchment have reached a level where the police have become involved.

Plate 1: a) Rice grown on the Fogera plains b) waterlogged maize
*(Photo Credit: Matthew McCartney, 2010)*

In the midlands, the terrain is much steeper with rock inselbergs in some places (Plate 2a) and the water table is deeper (ca. 12 -16 m). The Woreda agriculture office recommends the use of RWH ponds in preference to digging wells. To date 18 trapezoidal ponds lined with geo-membranes (Plate 2b) have been constructed in different kebeles of the Woreda. Each pond can store 129m$^3$ of water, sufficient to irrigate approximately 0.25ha. The Woreda office is planning the construction of 67 new water harvesting structures over the next year.
Information obtained from Woreta Agricultural and Rural Development Bureau indicated that over the past five years (2005-2009) there has been wider use of irrigation in Fogera Woreda which also increased productivity (Fig 2). At times farmers consider local market demands and act accordingly by changing the cropping type. The increased cost of onion and potato in year 2007, for example, caused local farmers to shift from rice and millet to onion and potato in year 2008 and resulted in increased productivity per hectare (Fig 2).

Plate 2: a) midlands in the Fogera woreda b) rainwater harvesting pond
*(Photo Credit: Matthew McCartney, 2010)*

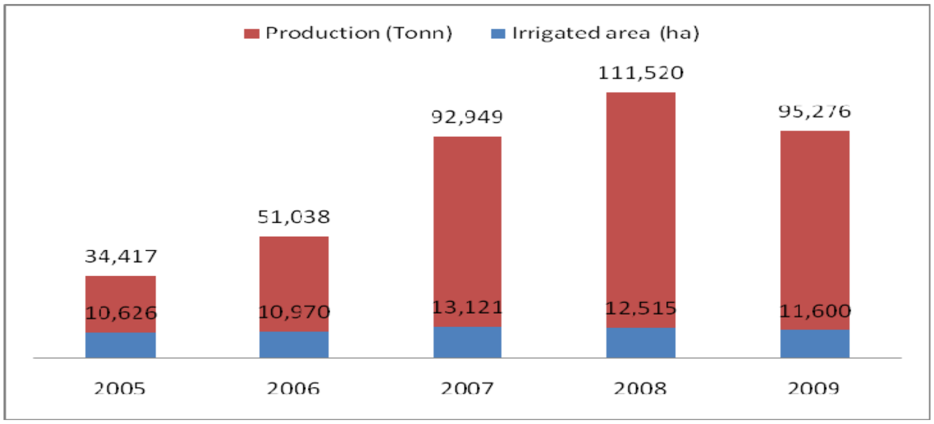


Fig 2 Irrigation statistics and productivity in Fogera Woreda
*(Source: Woreta Agricultural and Rural Developemnt Bureau)*

The action research catchment, which is on the hills and not in rice growing flood plain areas, various interventions are showcased. These include soil conservation practices: terracing, zai pits, hydrobasins afforestation and protected areas. Many of the interventions in the catchment have been undertaken by the community living in villages. The communities complained of

water shortages in the dry season which are attributed to upstream pumping and also the plantation of eucalyptus trees. There are at least three locations within the catchment where water is pumped for irrigation. This is resulting in the drying up of one of the tributary river (Ginde Newr) in the dry season. The communities also explained that RWH ponds were failing for a variety of “unforeseen” reasons.

**c) Jeldu Area**

The Jeldu area, located in the south of the Abbay basin to the north-east of Ambo is predominantly a highland area. The major river draining approximately south-north is the Meja River, a tributary to Guder River. The River originates at high altitude just outside Jeldu in the Dandi Woreda. The headwaters are in a flat wide valley, which is a wetland heavily utilized for livestock grazing (Plate 3a). It then drops steeply and flows through a relatively narrow deeply incised valley. Numerous tributaries drain into the Meja from both the east and west. These are also deeply incised – mountain streams - with relatively small catchments (i.e. typically 3-4 $km^2$) (Plate 3b).

Plate 3: Meja River catchment: a) the upper catchment – a broad valley b) mid-catchment - deeply incised valley.
*(Photo Credit: Matthew McCartney, 2010)*

Most communities live on the ridge tops but cultivate the steep valley sides. Slopes of up to $80^o$ are being cultivated. Where slopes are too steep for tilling by oxen people use hoes. The area has been heavily deforested in the last 10-20 years and erosion is a major problem. Both slope slumping and gulleying are common phenomena (Plate 4).

There are not many interventions as regards to soil water conservation or RWM. Farmers plant eucalyptus (currently occupying approximately 10-15% of the landscape) to mitigate gulley expansion and generate cash income by planting it along the gully line and on degraded areas. In the Woreda some farmers believe productivity has “halved” in recent years. Twenty three kebeles are food insecure with seasonal water scarcity.

Within the action research catchment there are some traditional diversions for irrigating potatoes, maize and onions. However, water scarcity prevails due to competing use/need between the upstream and downstream residents with reducing volume of streams flow during the dry season.

Plate 4: Gulleying in the catchment of the Meja River.
*(Photo Credit: Matthew McCartney, 2010)*

## 5. Guiding Principles towards effective RWM Strategies -Lessons from INDIA

According to water resources research report (WRI Report, 2003) effective RWM strategies are best achieved on a micro-catchment basis. The approach emphasizes self-help, ecological regeneration and "catching rain wherever it falls". This principle addresses the need to work on different water storages options. This means the full range of water storage options in catchments need to be considered – water storage in soil moisture, wetlands, water harvesting structures and groundwater (Annual Report, 2009). For example recharging aquifers with rainwater that would otherwise run-off has been a very successful approach in Tamil Nadu, Maharashtra and Gujarat states of India. WRI Report (2003) presents a series of rigorous watershed development activities that should be practiced at micro-catchment level for effective RWM programs as follows:

- Establishing Village Self-Help Groups to help guide the watershed effort;
- Building Hydraulic structures for in-situ water harvesting, aquifer recharge and erosion control;
- Planting trees and grasses to stabilize waterways and provide fodder and fuel wood;
- Instituting bans on tree felling and grazing for natural regeneration of shrubs and grasses;
- Training villagers in new or improved agricultural practices and livelihood activities and;
- Supporting cottage industries and supplemental income generation through micro-lending schemes.

The next section of the paper describes mechanisms of RWM through watershed development approaches.

## 6. Practical applications through watershed development

A watershed is an area that harvests rainwater, stores it underground and/or channels it into a stream, a waterway and a river. In the context of RWM strategies watershed development refers

to the conservation, regeneration and judicious utilization of all the resources - land, water, vegetation, animal and human-within a particular watershed (WOTR, 2009). Apart from improving RWM, watershed development can help the communities living in the area improve their capacity for adapting to the impacts of climate change (WRI Report, 2003).

Watershed development seeks to bring about an optimal equilibrium in the eco-space between natural resources, man and animals. This is possible by developing micro-watersheds comprehensively so as to create sustainable livelihood opportunities for local inhabitants. The approach helps to reclaim degraded lands through the regeneration and sustainable management of watersheds and increase the use of water. The principle stated by WOTR (2009) "***where the rain runs, we make it walk; where it walks, we make it crawl; where it crawls, we make it sink in to the ground"*** helps to reduce runoff and raise the water table. The practice is extremely important for agriculture, growth of forage and supplies of water for rain-fed cultivation.

### 6.1 Treatments for watershed development to conserve rainwater

In order to conserve rainwater in-situ and enhance soil fertility and aquifer recharge, there are three basic operations: area treatments, drainage line treatments and afforestation and pasture development. These operations need to be conducted from ridge to valley at a micro-catchment level as presented below.

#### A. Area Treatments

Area treatments refer to practices that are made in the watershed to incrementally slow down fast flowing water until some of it stops flowing. These include construction of Continuous Contour Trenches (CCT) or hillside terraces, stone bunds, soil bund, and contour vegetation strip (Plate 5). These practice result in control of erosion, retention of soil fertility, better soil moisture regime, infiltration and ground water recharge. The stone bunds or stone faced trench bunds technology, for example, is widely adopted by many farmers in Ethiopia to retain rainwater that becomes runoff and later causes erosion. The technology is essentially a water harvesting practice intended to store rainwater for crop production and enhance ground water recharge. The technology has its origin in India and has been practiced in Blue Nile basin, Tigray region, North Shoa and Awash basin (SLMP, 2010).

Area treatments like biophysical measures (Ditchra and cutoff drains) that are integrated with area enclosures are common practices in the southern parts of Ethiopia, for example in Alaba Woreda, to help maintain the productivity of degraded land which has been abandoned. Through this technology, unproductive and waste lands are changed to productive land by the prevention and reduction of erosion and enhance land rehabilitation (SLMP, 2010). Vegetated Fanya juu, that is construction of soil embankment along the contour stabilized with biological measures such as grass, fodder trees and shrubs, fruit trees and cereals of high economic value are a RWH technology practiced in Omo-Sheleko of Southern Ethiopia. The technology provides multiple benefits of controlling runoff velocity and soil erosion, change the slope steepness, recharge ground water, retain soil moisture and increase land productivity. The technology is more effective in gentle and flatter slopes. For steeper slopes soil bunds are recommended (SLMP, 2010).

Vegetated stone-soil bunds are practiced in high rainfall regimes and steeper slopes to reduce the effect of flood problems. In the process of controlling soil erosion in the upper watershed, the use

of vegetated stone-soil bunds, offer safety to cultivated lands at the valley bottoms. In the Farta Woreda which is closer to Fogera Woreda paved and grassed water way technology is practiced in 34 kebeles as an effective mechanism to trap and direct rainwater to natural drainage systems safely. The technology was found to be suitable to steeper areas receiving high rainfall to enhance moisture and water harvesting, effective soil erosion control and prevention of gully erosion (SLMP, 2010).

(a) Continuous contour trenches (b) Stone Bunds across the slope (c) Vegetation Bunds and plantations along CCTs
Plate 5: Few examples of area treatments.
*(Photo Credit: Birhanu, 2010 from INDIA)*

CCTs or hill side terraces (Plate 5 (a)) are practiced in low to high rainfall (250-3000mm) regimes, and mild to steeper slopes (5 to greater than 60% slopes). The technology breaks the speed of fast moving water, trap rainwater and enable it to percolate to underground aquifers. The technology avoids the use of stones in farmlands and has got positive perception of its usefulness and active promotion by extension service in Ethiopia (SLMP, 2010). Stone Bunds across the slope (Plate 5 (b)) arrest the flow of water and control erosion in areas where soil work is not possible. Vegetative bunds and plantation along CCTs (Plate 5 (c) increase biomass, conserve water and control erosion. Contour Bunds and Field Bunds on waste lands and arable lands also improve soil moisture retention and control erosion and promote the growth of grasses, trees and tree crops.

**B. Drainage Line Treatments**

Drainage line treatments entail, beginning from the top, a series of gully plugs, earthen and stone dams and masonry structures which would allow surplus runoff, which has already been considerably slowed down, to accumulate and get stored along the entire drainage line, thus ensuring rapid and substantial groundwater recharge and the creation of water banks.

(a) Gully plugs along drainage line

(b) Nala Bunds along drainage line

(c) Check dam along the drainage line

(d) Percolation tank along the drainage line

Plate 6; Few examples of drainage line treatments.
*Photo credit: Birhanu (2010) from INDIA*

Gully Plugs and Nala Bunds help control the flow of water, sedimentation and recharge ground water aquifers. Check dams and percolation tanks are constructed at the lowest end of the drainage outlet and serve as storage basins for surplus Ridge to Valley conservation runoff water.

### C. Afforestation and Pasture development

This refers to plantation of trees, grasses and shrubs that meet household needs of fuel, fodder, timber, fruits and fiber. In areas where soil depth is not sufficient, pastures need to be developed. The trees, shrubs and grasses not only add organic matter to the soil, but also control erosion, cushion the 'hammer effect' of falling rain, slow runoff and accelerate infiltration. With assured nutritious fodder and appropriate land use patterns, livestock intensification up gradation, especially milk cattle, is facilitated, which often results in higher income and less biotic pressure on grazing grounds.

## 7. Conclusions and Recommendations

This paper presented mechanisms for achieving effective RWM strategies over the next three years in the Ethiopian Highlands through watershed development approaches that have been practiced in India and Ethiopia. In areas of their application, the approaches have often contributed to increased food security and increased livelihood services for the poor. However, where badly implemented they can have the opposite effect, increasing poverty and worsening

food security. It is therefore essential that interventions are well planned and implemented. Further research, of the sort planned in the current study will provide knowledge that can contribute to better understanding of the factors that make interventions successful.

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